INDIAN RECEPTION OF MUSLIM VERSIONS OF PTOLEMAIC ASTRONOMY

David Pingree

The history of astronomy, as of all other aspects of human thought, is extraordinarily complex. Much of that complexity is reflected in the subject I am about to address. For both Indian and Muslim conceptions of the forms of the heavens and earth and of the mathematics by which their several motions may be described originated in Hellenistic astronomy, but each descended through various different cultural milieus to become transformed into models, parameters, and mechanisms barely recognizable to each other. In this paper, expanding on what I have previously written on this subject[1] but striving not to repeat excessively what has already been said, I intend to examine how some Indians attempted to make the Muslim interpretation of Ptolemy palatable to their fellows, who frequently dismissed it as foreign rubbish,[2] while others tried to use elements of it simply to buttress the, for them, naturally declining system revealed at the beginning of the yuga by the divine knowledge of the Sun.

For in the tradition of the astronomies of India it had become, by the sixteenth century in Northern India, important to many scientists to emphasize the origin of one's pakṣa or school in a revelation granted by either a divinity or an ṛṣi.[3] The main rivals in the resulting wars of revelations were Brahmā, the creator and recreator of this universe, from whose *Paitāmahasiddhānta*[4] both the Āryapakṣa of

---

[1] See D. Pingree, "Islamic Astronomy in Sanskrit," *Journal for the History of Arabic Science* 2 (1978): 315–330 [henceforth "Islamic Astronomy"]; and id., "History of Mathematical Astronomy in India," in *Dictionary of Scientific Biography*, vol. 15 (New York, 1978), pp. 533–633, esp. pp. 625–629 [henceforth "History"].

[2] See, e.g., Munīśvara and Gadāhara cited in "Islamic Astronomy," pp. 321–322.

[3] See, e.g., Nṛsiṃha and Kamalākara cited in D. Pingree, "The Purāṇas and Jyotiḥśāstra: Astronomy," *Journal of the American Oriental Society* 110 (1990): 274–280 at 279 [henceforth "The Purāṇas"].

[4] See D. Pingree, *Census of the Exact Sciences in Sanskrit*, Series A, vols. 1–5 (Philadelphia, 1970–1994) [henceforth *CESS*], A4, 259a; and "History," pp. 555-565.

Āryabhaṭa[5] and the Brāhmapakṣa of Brahmagupta[6] truthfully claimed descent, and Sūrya, the Sun god, whose *Sūryasiddhānta*,[7] which had been updated in the sixteenth or seventeenth century,[8] was in fact principally based on the Ārdharātrikapakṣa of Āryabhaṭa,[9] itself a modification of his Āryapakṣa. There are several other divinities and ṛṣis who are quoted as authorities; but, in fact, all of the siddhāntic tradition of cosmology, geography, and mathematical astronomy goes back to Indian adaptations in the fifth century of Greek models and parameters altered to fit existing Indian theories expressed in the Purāṇas.[10]

The cosmology (khagola) of the siddhāntas conceived of the universe (insofar as we can perceive or deduce it) to consist of nine internested spheres, one for each of the seven planets in the Hellenistic order, the eighth bearing the nakṣatras, and the ninth being the sphere of heaven. The distances of the planetary spheres from each other is based on the theory, adumbrated by Plato, that the distance of each from the center of the earth is inversely proportional to its planet's mean velocity. While the inner eight spheres are rotated daily by the pravaha wind which is wrapped around their common axis, each planet moves independently on its own concentric orbit in a motion that is irregular because of the pulls exerted on the planet by demons stationed at the uccas on its manda and śīghra epicycles. The forces that move the celestial bodies, then, are material beings, whose execution of their self-appointed tasks is certainly not eternal, since this cosmos within the Brahmāṇḍa is destroyed and recreated to the rhythm of a Kalpa of 4,320,000,000 years; nor is it necessarily constant, since the world declines drastically over the course of a Mahāyuga of 4,320,000 years. These ideas allowed Indian astronomers, if they so chose, to justify the introduction of foreign models

---

[5] See *CESS* A1, 53a–53b; A2, 15b; A3, 16a; A4, 27b; and A5, 14a–15a; "History," pp. 590–593; and D. Pingree, "Āryabhaṭa, the Paitāmahasiddhānta, and Greek Astronomy," *Studies in History of Medicine and Science* 12, no. 1–2, NS (1993): 69–79.

[6] *CESS* A4, 254b–255b, and A5, 237b; and "History," pp. 565–580.

[7] A full bibliography of the *Sūryasiddhānta* will appear in *CESS* A6; for now see D. Pingree, *Jyotiḥśāstra*, (Wiesbaden, 1981), pp. 23–24; and "History," pp. 608-610.

[8] "History," pp. 617–618.

[9] "History," pp. 602–608.

[10] See "The Purāṇas" and D. Pingree, "The Recovery of Early Greek Astronomy from India," *Journal for the History of Astronomy* 7 (1976): 109–123.

and parameters, which could be regarded as representing the degeneration of what had existed and been described by a god or an ṛṣi at the beginning of the yuga. But this cosmology precluded most from embracing Aristotelian concepts of natural motion. Though the Indians like Aristotle had five elements (mahābhūtas), they—earth, water, air, fire, and space—all permeate the entire cosmos; in this the Indians were closer to Plato than to his pupil. Muslim astronomers, of course, being devotees of the Stagirite, believed in a radical difference between the sublunar world of naturally linear motion and celestial spheres of naturally circular motion, which ought as well, at least in principle, to be uniform and concentric.

The Indian sphere of the earth (bhūgola) was dominated by the enormous Mt. Meru at the North Pole around which spread over all of the Northern hemisphere the inner continent called Jambūdvīpa, the island of the rose-apple tree, with Bhāratavarṣa or India and Laṅkā to the South (the city which Muslim astronomers of the ninth century had already learned to call the qubbat al-arḍ or Cupola of the Earth), Romaka or Rome to the West, the Siddhas to the North, and Yamakoṭi, the Castle of Yama, to the East. Around Jambūdvīpa flows the ocean of salt water; and the Southern hemisphere is covered by alternating rings consisting of the six remaining continents and six remaining oceans of the Purāṇas, while at the South Pole lies the Vaḍavāmukha, the Mare's Mouth.

As I indicated with respect to the qubbat al-arḍ, this Indian cosmology and geography were familiar to Muslims in the late eighth and the ninth centuries through Arabic translations of both Pahlavī and Sanskrit astronomical texts.[11] But even in this earliest period of Islamic astronomy the Ptolemaic system was also known—for instance, in the work of Māshā'allāh preserved for us in a Latin translation by Gerard of Cremona as the *De elementis et orbibus cœlestibus*, though he also describes Indian models for the planets.[12] This is the earliest treatise in Arabic that can be said to belong to the class of texts called ᶜilm al-hay'a. Later members of this class include the *Kitāb al-tadhkira fī ᶜilm al-hay'a* composed in Arabic by

---

[11] See D. Pingree, "The Greek Influence on Early Islamic Mathematical Astronomy," *Journal of the American Oriental Society* 93 (1973): 32–43.

[12] See D. Pingree, "Māshā'allāh: Some Sasanian and Syriac Sources," in *Essays on Islamic Philosophy and Science*, ed. G. F. Hourani (Albany, N.Y., 1975), pp. 5–14, esp. pp. 9–12.

Naṣīr al-Dīn al-Ṭūsī in 1261[13] and the *Risālah dar hay'ah* written in Persian by ᶜAlī al-Qūshjī in the 1450s or 1460s.[14] Both were important for the transmission of Islamic astronomy to India; and both contain in general the same sort of information. The *Tadhkira* is divided into four books containing, respectively, mathematical and physical principles; the configuration of the celestial spheres; geography; and the sizes and distances of the earth and the celestial bodies. The *Risālah dar hay'ah* in an introduction and two books treats in far simpler form the same material (in the way that al-Qūshjī conceives of it) as is contained in the first three books of the *Tadhkira*. The readers of these two works, then, are introduced to basic definitions of Euclidean geometry; the five elements and the Aristotelian principles of their motions (Aristotelian principles are omitted by al-Qūshjī); the arrangement of the celestial spheres, of which there are nine as in the Indian tradition, and the spheres of the four sublunar elements; the great and smaller circles on the celestial spheres that are used in astronomy; the solar, lunar, and planetary models and parameters; geography insofar as it is related to astronomy (e.g., the seven climata and terrestrial longitudes and latitudes); and, at least in the *Tadhkira*, the sizes of the earth and of the celestial bodies, and the distances of the latter from the earth. Clearly the main elements of the Islamic tradition that Indian astronomers would find difficulty in receiving are the Aristotelian notions of the causes of physical motions and those features of the arrangement of the spheres and of the planetary models that depend on the Islamic interpretation of how Aristotelian philosophy and physics impose changes in Ptolemy's system.

The translation of Arabic or Persian astronomical texts into Sanskrit presupposes the existence of bilingual individuals and, at least ideally, of technical dictionaries. The oldest Persian-Sanskrit dictionary that we have constitutes the first prakaraṇa of the *Pārasīprakāśa* composed by Kṛṣṇadāsa in the late sixteenth century for the Emperor Akbar.[15] While it contains a number of words that occur in astronomical texts—for example, the names of the planets

---

[13] Edited by F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī's* Memoir on Astronomy, 2 vols. (New York, 1993).

[14] An edition of the Persian together with an anonymous Sanskrit translation, the *Hayatagrantha*, is being prepared by D. Pingree and K. Plofker.

[15] See *CESS* A2, 57a–57b; A4, 61b; and A5, 49a.

and words designating measures of time—it is bereft of all of the technical vocabulary of mathematical astronomy. More detailed information concerning the Persian calendar, and, after an excursus on the technical terms of astrology, the Persian words used in arithmetic, trigonometry, and astronomy can be found in a second *Pārasīprakāśa*, that written by Mālajit in 1643, a work for which the title Vedāṅgarāya was bestowed on him by Shāh Jahān.[16] However, in the manuscripts that I have examined,[17] this unpublished text contains only the vocabulary contained in the *Risālah dar hay'ah* up to the end of the third bāb of the first maqāla; the next bāb takes up the planetary models, whose technical vocabulary Mālajit does not discuss.

The date of the Sanskrit translation, entitled *Hayatagrantha*, of al-Qūshjī's *Risālah dar hay'ah* and the name of the translator are both unknown.[18] The earliest dated manuscript that has been discovered, though it is now lost, was copied in 1694, during the long and unpleasant reign of Aurangzeb. I suspect that the translation was made earlier in the seventeenth century, under Jahāngīr or Shāh Jahān, but that dating can not as yet be either confirmed or denied. I should only report that transliterations found in the *Hayatagrantha's* prose are not always identical with those in the Vedāṅgarāya's poetry, but that this fact obviously can not be used to substantiate a claim that the Vedāṅgarāya did not use the *Hayatagrantha*.

The *Risālah dar hay'ah* is not a philosophically oriented text, so that there are in it no direct statements about the laws of Aristotelian physics as there are in the *Tadhkira*. Therefore, the anonymous translator had no difficulty beyond the linguistic in converting it into Sanskrit. He was clearly helped by a collaborator who was versed in Persian and Islamic astronomy, at least at a level sufficient for understanding the *Risālah*; this is clear from the existence of small additions meant to explain the Persian text to the Sanskrit reader. Moreover, a few phrases in the Persian text, mostly of a pious nature, which were felt to be inappropriate for a Hindu audience, were omitted. Otherwise, everything is straightforward, including the planetary models with all their normal Muslim solid spheres sur-

---

16 See *CESS* A4, 421a–421b; and A5, 305b–306a.

17 MS British Library Add. 14,357b; MS London, India Office Library 2114d; and MS Sarasvatī Bhavana, Benares 35337 (with his own ṭīkā, the *Pañjikā*).

18 See "Islamic Astronomy," pp. 326–328; and *CESS* A4, 57a–57b.

rounding eccentrics and equants, their epicycles, and long explanations of how they function to produce the apparent motions of the Sun, the Moon, and the planets. The collaborator is even learned enough to add what is not in the Persian, the information that ᶜallāma Qūshjī, the son of Ulugh Beg's teacher, determined the obliquity of the ecliptic to be 23;30,17°.

However, sometime in the eighteenth century an unknown astronomer interfered with the original translation by adding material, some from the *Sūryasiddhānta* and some from his own wit. So, after al-Qūshjī reports that he observed the Sun's apogee to be at Cancer 2;26° in Muḥarram of 841 AH (July 1437 A.D.), the interpolator computes that, starting from the *Sūryasiddhānta's* solar apogee at Gemini 18° and using al-Qūshjī's rate of precession, 1° in 70 years, the Sun's apogee was in Cancer 2° in 1178 A.H. (which began on 1 July 1764).[19] If the interpolator's date can be fixed from this as about 1765,[20] his location is indicated by his several references to Kāśī—i.e., Benares. In general, the interpolator is someone familiar with both Persian astronomy and the *Sūryasiddhānta*; his interventions are intended to provide comparisons between the two systems.

I do not wish to discuss here the controversy that took place in Kāśī during the reign of Shāh Jahān between two rival families of astronomers, one of which incorporated elements of Islamic astronomy into their otherwise Indian siddhāntas, and the other of which often but not consistently vigorously opposed such practices. I have written at some length—though by no means exhaustively—about this conflict elsewhere.[21] Rather, I would like to examine part of the *Sarvasiddhāntarāja* composed by Nityānanda at Delhi in 1639.[22] Previously, Nityānanda had translated Farīd al-Dīn Ibrāhīm al-Dihlawī's *Zīj-i Shāh Jahān* into Sanskrit for Āsaf Khān;[23] the epoch of that work was in the year in which Shāh Jahān began to reign, 1628. Since the *Zīj-i Shāh Jahān* was based on the *Zīj* of

[19] *Hayatagrantha*, ed. V. Bhaṭṭācārya, (Vārāṇasī, 1967), p. 69.

[20] Note that the one Benares manuscript that does not contain the interpolator's remarks, Sarasvatī Bhavana 36934, was copied by Nāgeśa on 16 September 1765.

[21] "Islamic Astronomy," pp. 320–323.

[22] "Islamic Astronomy," pp. 323–326, and *CESS* A3, 173b–174a; A4, 141b; and A5, 182a. I have used the manuscript, now γ 550, in the Wellcome Institute in London.

[23] See *CESS* A3, 173b; A4, 141a–141b; and A5, 182a.

Ulugh Beg as was al-Qūshjī's *Risālah*, Nityānanda's models and parameters in the *Sarvasiddhāntarāja* generally agree with those in the *Hayatagrantha*. But whereas the latter makes no attempt to disguise its foreign origin—all technical terms are first transliterated from the Persian, and then explained in Sanskrit—Nityānanda has felt it necessary, or at least useful, to adopt several interesting stratagems to seduce his readers into believing that he is impeccably orthodox. It is this aspect of his work that I wish at present to review.

After an unexceptional verse in which he pays his homage to Brahmā, he cleverly associates astronomical systems described by gods and by ṛṣis with that proclaimed by Romaka—by which appellation he means both the author of the third-century *Romakasiddhānta* summarized by Varāhamihira in his *Pañcasiddhāntikā*[24] and the Romaka or Muslim whom, as we shall see, he pretends to be the ultimate human authority for Ulugh Beg's astronomy:

> śrīsūryasomaparameṣṭhivasiṣṭhagargā-
> cāryātriromakapulastyaparāśarādyaiḥ||
> tantrāṇi yāni gaditāni jayanti tāni
> sphurjaddhiyā gaṇitagolasphuṭāni||
>
> Those treatises are victorious which are accurate in
> mathematics and spherics because of (their
> authors') flashing intelligence (and) which were
> proclaimed by (the gods) Sūrya, Soma, and Brahmā
> (and by the ṛṣis) Vasiṣṭha, Garga, Atri, Romaka,
> Pulastya, and Parāśara.

Having thus inserted Romaka among the ṛṣis, he in the next verse praises the human Bhāskara, who like Maya, Āryabhaṭa, and Brahmagupta, followed the pakṣa of Brahmā. And next he claims that in general his efforts have been directed toward investigating Bhāskara's treatise without the modifications added through their own intelligence by others who are far distant from the siddhāntas composed by divinities such as are the Sun and the Moon, siddhāntas filled with good applications of arithmetic, the solution of indeterminate equations, algebra, and the arrangement of the spheres.

---

[24] See *CESS* A5, 562a–562b.

After several more verses proclaiming his intent to produce a simpler text while staying within the Indian tradition, Nityānanda states that he is writing the *Siddhāntarāja* after investigating what he calls the *Romakasiddhānta* (that is, Ulugh Beg's *Zīj*), the *Sūryasiddhānta*, and the *Brāhmasphuṭasiddhānta* of Brahmagupta, of which trio he claims that the Romaka agrees best with observation, though men know that the *Sūryasiddhānta* is like a Veda and that the *Brāhmasphuṭasiddhānta* contains useful methods. He then plunges into the story originally employed in the introduction to an early recension of the *Jñānabhāskara* cast in the form of a dialogue between Sūrya and his charioteer, Aruṇa—a dialogue to which Nityānanda directly refers. According to this story, the Sun, because of the curse of Brahmā, became a Yavana (in the seventeenth century Yavana meant Muslim) in the city of Romaka and was known as Romaka. After the curse was lifted, he became the Sun again, and wrote the *Romakasiddhānta* "which has the form of revelation (śrutirūpam)." It is this work in its entirety that Nityānanda claims now to be repeating.

Our author, then, has substituted the Sun god, Sūrya, for Farīd al-Dīn Ibrāhīm, and he has elevated the science of the Mlecchas to the level of a Veda. This theme is expanded by his later assertion that, though the siddhāntas produced by the gods and ṛṣis are phrased differently, the astronomy is always the same; they all follow the *Sūryasiddhānta*. But human authors can and do err from the divine path. However, the gods and the munis present an astronomy designed to be applicable to dharmaśāstra—i.e., to the determination of the proper times for performing rituals and for observing festivals—and applicable to astrology, while humans deduce certain parameters from observation. Nityānanda's solution to the dilemma of having contradictory theories is typical in India: one is to use both, each in the situations appropriate to it. There exist a plurality of truths, each of which has its proper application. Nityānanda expresses his general criterion of truth in the following verse:

> yad yad uktam ṛṣibhiḥ kila devais
> tat tad atra sakalaṃ saphalaṃ hi||
> pūruṣair aviditāgamatattvaiḥ
> kṣiptam ūharahitaṃ tad asatyam||

> Whatever was said by the ṛṣis and the gods, all of that is here; it is indeed fruitful. That which is added by men who do not know the truths of the sacred books, that which is lacking investigation, is false.

Nityānanda, then, accepts the siddhāntas composed by gods or ṛṣis as true regardless of what they say, while asserting that everything they say is in agreement with the *Sūryasiddhānta*; and he will accept what men say in addition only if it results from investigation, i.e., is properly inferred in accordance with the rules of traditional Indian philosophy, which include perception as one of the bases for valid knowledge.

In the first chapter, then, Nityānanda has established the orthodoxy of his composition of a siddhānta expounding Islamic astronomy by placing Romaka, his stand-in for Farīd al-Dīn, among the ṛṣis; by making him an incarnation of the Sun; by proclaiming the peaceful coexistence of mutually contradictory truths; and by taking the normal Indian position that, while the gods and ṛṣis always speak the truth, man through his own intelligence may discover additional truths that have their proper applications. In the second chapter he endeavors further to justify what he is doing by employing the traditional Indian divisions of time, including the theory of Kalpas, Mahāyugas, and Yugas, as a framework within which to transform Islamic into Indian astronomy. For he converts the Muslim perpetual mean motions of the planets and the longitudes of their apogees and nodes into the standard Indian form of integer numbers of rotations in a Kalpa; though, because they do not properly fit, he is obliged to add bījas or corrections at the end, another traditional Indian device. These bījas, he claims, were determined by observation. To emphasize how close the mean longitudes computed according to the *Zīj-i Shāh Jahān* are to those computed with Indian methods, he compares them with results from the *Sūryasiddhānta* and the Brāhmapakṣa; indeed, they are not very different, as is not very surprising.

In the next chapter Nityānanda compares the parameters of the solar, lunar, and planetary models in the so-called *Romakasiddhānta* with those in the *Sūryasiddhānta* and those in Brahmagupta's *Brāhmasphuṭasiddhānta*. The numbers are simply juxtaposed, without comment. This is followed by an elaborate and lengthy explanation of the finding of the Sine of an arc, the sum or the difference of

the Sines of two given arcs, and so on, culminating in the construction of a table of the Sines for every minute of arc between 0° and 90°. All this, of course, represents Ulugh Beg's and al-Kāshī's amplification of the Sine function originally introduced by Indian astronomers in the fourth or fifth century A.D.

Nityānanda proceeds to instruct his reader on how to compute a longitude or a latitude with the Romaka's models. These are indeed the models of the Islamic Ptolemaic tradition with the crank-mechanism and the prosneusis of the Moon, the double eccentricity and the equant of the superior planets and Venus, and the triple eccentricity and crank-mechanism of Mercury. But the geometrical solution for finding the planet's longitude according to each of these models is simply a modification of the methods employed in the siddhāntas for single or double epicycle models.

Having made his points that the Romaka is of impeccably divine origin, that its results are close to those obtained by an already internally divided Indian tradition, and that its innovations are useful, Nityānanda introduces a miniature ᶜilm al-hay'a text discussing geometrical principles, the configuration of the four elemental and nine celestial spheres, and the models of the Sun, the Moon, and the planets. This is followed by elaborate directions for drawing diagrams of these models on a wall in order to instruct one's students. These are, of course, the diagrams familiar to us from both Arabic and Persian manuscripts and their imitations in medieval Latin codices and fifteenth- and sixteenth-century printed books, though the three manuscripts of the *Sarvasiddhāntarāja* that I have been able to examine are not illustrated,[25] though spaces are left for some diagrams in the Wellcome's copy.

A text which does have such diagrams, at least in the two manuscript copies that I have consulted,[26] is the *Jyotiḥsiddhāntasāra* composed by a Mālavīya Brāhmaṇa named Mathurānātha Śukla.[27] He was teaching astronomy to school-children in Kāśī when he was requested by a Rāja, Ḍālacandra, to write a book on the subject. He completed the present work in 1782 and added a commentary which

---

[25] Besides the Wellcome manuscript, I inspected manuscript 206 of A1883/84 at the Bhandarkar Oriental Research Institute, Poona, and manuscript 2619 at the Rajasthan Oriental Research Institute at Alwar.

[26] These are R.15.124 and R.15.125 at Trinity College, Cambridge.

[27] See *CESS* A4, 349a–350a; and A5, 272b.

presumably helped his students as much as it does us to understand the full details of his adaptation of an as yet unidentified work on hay'a, though its parameters in general are again those of Ulugh Beg.

Following the standard pattern of an ᶜilm al-hay'a text, Mathurānātha begins his khagolavicāra with geometry and the Aristotelian physical principles of motion. There follow descriptions of the celestial spheres, a Ptolemaic-style catalogue of 1025 stars arranged in 48 constellations (missing but alluded to in both the manuscripts available to me), descriptions with parameters of the Islamic Ptolemaic models for the Sun, the Moon, and the planets, latitude theory, the heliacal risings and settings of the planets, and solar and lunar eclipses. The bhūgolavicāra describes the seven climata with their maximum daylights and median terrestrial latitudes, the coordinates used in Islamic mathematical geography, particulars of the seven regions, sunrise and twilight (he knows Ibn Muᶜādh's estimation that it begins or ends when the Sun is 18° below the horizon), some elements of the Phārisī, Rūmī, and Mālikī calendars with remarks on the year of the Phiraṅgis, methods for determining the time of day, the establishing of the distance between two localities by means of simultaneous observations of a lunar eclipse, and the dimensions of the universe measured in farsangs. Though Mathurānātha when necessary uses a Persian word, overwhelmingly his vocabulary is taken from the Sanskrit siddhāntas; and from time to time he inserts, especially into his commentary, information about traditional Indian views concerning the subject that is being discussed in his Persian source. It is not entirely clear what his (or the Rāja's) purpose was in instructing the students, who must have been Brāhmaṇas, in the basic elements of Persian astronomy. It is difficult to believe that they wished the younger generation of Hindus to become more tolerant of Muslims through a knowledge of their astronomy, but other possible motives do not immediately present themselves.

The motivation of Mathurānātha's predecessor, Jayasiṃha,[28] in studying Islamic astronomy is much clearer. Despite all the enthusiasm that he continues to arouse as the man who introduced "modern" science into India, he was in fact a very devout and pious Hindu who believed firmly that the siddhāntas attributed to the gods

---

[28] See *CESS* A3, 63a–64b; A4, 97b; and A5, 115b–116a.

and the ṛṣis, but particularly the *Sūryasiddhānta*, are true. It is for this reason that he had his pandits write a *Sūryasiddhāntavyākhyā* describing and defending that work's cosmology and planetary models while explaining away any observed defect,[29] and it is for this reason that he had his Jyotiṣarāya, Kevalarāma,[30] write the *Brahmapakṣanirāsa*[31] in which he attempts to show that the tradition of the *Paitāmahasiddhānta* of the *Viṣṇudharmottarapurāṇa*, the *Brāhmasphuṭasiddhānta* of Brahmagupta, and the *Siddhāntaśiromaṇi* of Bhāskara does not have a solid foundation since they are not based on the words of either a god or an ṛṣi. Only the *Sūryasiddhānta* has such a basis, and so do those other works by gods and ṛṣis which are the occasional expressions of the theories of Sūrya in varying verbiage. Clearly this is a view close to that voiced by Nityānanda. And we must conclude that like Nityānanda Jayasiṃha allowed the epithet "true" to be accorded to valid inferences from observed phenomena. Unlike his seventeenth-century predecessor, however, Jayasiṃha did not adapt in Sanskrit the Islamic Ptolemaic models of the universe or of the mechanisms producing the motions of the Sun, the Moon, and the planets. The opening verses of Kevalarāma's *Brahmapakṣanirāsa* correctly describe his basic attitude:

> vedāḥ sampāditā yena teṣāṃ vistāritāḥ kriyāḥ||
> varṇāśramavibhāgaś ca viluptaḥ sthāpitaḥ punaḥ||
> pātitāḥ puṣkare tīrthe paurohityāt padodbhavāḥ||
> śrīsavāīnareśas tu śrautasmārtārthasiddhaye||
> anarham ity asau jñātvā brahmapakṣaṃ nirāsyati||

> He who caused the Vedas to succeed has spread abroad their rituals; the division of the varṇas and the stages of life had slipped, but are restored again; because of his being a purohita the lotuses are caused to fall in the pilgrimage site at Puṣkara lake. In order to achieve the meaning of śruti and smṛti (the Vedas and dharmaśāstra) the king, Savāī

---

[29] I have used manuscript 29498 of the Rajasthan Oriental Research Institute at Jodhpur.

[30] See *CESS* A2, 63a–63b; A4, 63b; and, most importantly, A5, 52a–52b.

[31] I have used manuscript 28628 of the Rajasthan Oriental Research Institute at Jodhpur.

> (Jayasiṃha), recognizing that the Brahmapakṣa is
> unworthy, annihilates it.

There is not a hint in the *Brahmapakṣanirāsa* of the existence of Islamic, European, or any other Mleccha astronomy.

But Jayasiṃha did, for his own purposes of correcting parameters in this decaying universe,[32] construct observatories and sponsor the translations into Sanskrit of Theodosius' *Spherics*, Euclid's *Elements*, Ptolemy's *Almagest*, and at least parts of some contemporary European works on astronomy. He also had translated, by Nayanasukha with the help of a Persian assistant, Muḥammad Ābidda, the Arabic commentary by al-Birjandī on the eleventh chapter of the second book of Naṣīr al-Dīn's *Tadhkira*[33]—the chapter in which al-Ṭūsī discusses his new models employing the Ṭūsī-couple—while al-Birjandī, in his sharḥ, reports at length on the criticisms of Ptolemy issued by Ibn al-Haytham and on some of the work done by Persian astronomers after Naṣīr al-Dīn, notably by Quṭb al-Dīn al-Shīrāzī in his *Al-tuḥfa al-shāhiyya* and in his *Nihāyat al-idrāk*. The translator and his Persian assistant obviously discussed the meaning of many passages in this dense and difficult book; in some cases they decided that an expansion was necessary to render the text meaningful, and a few times they despaired of rendering a translation and simply omitted a difficult passage. But in general they performed their task well; highly technical Arabic terms are retained in their Persian forms in Sanskrit transliteration, but usually with an explanation of their meaning when they are introduced. An intelligent reader could certainly have made sense of this text; but, so far as we know, it had no readers at all. The unique manuscript was copied by one of Jayasiṃha's scribes, Kṛpārāma, in 1729.[34] This was probably the first copy of Nayanasukha's draft, and, as far as we know, no other copy was ever made. Jayasiṃha received this most important document of the Marāgha School into his library in 1730, but never into his astronomy.

---

[32] Concerning Jayasiṃha's attitude, see D. Pingree, "Indian and Islamic Astronomy at Jayasiṃha's Court," in *From Deferent to Equant* (New York, 1987), pp. 313–328, esp. pp. 315–318.

[33] An edition of the Arabic original of al-Birjandī's sharḥ on *Tadhkira* 2,11 together with Nayanasukha's Sanskrit translation is being prepared by T. Kusuba.

[34] This is manuscript 46 in the collection of the Palace Museum at Jaipur.

Our two most intelligent and informed authors, Nityānanda and Jayasiṃha, have unwittingly exposed a set of basic differences between the Hindu and the Muslim scientific views of astronomy. The Muslim believes, as a Greek would, in the uniformity of nature over distances in time and space, while the Hindu believes that the universe decays over time and that the planets may move differently over Bhāratavarṣa and over the Mlecchas. Moreover, the heavenly spheres perform social functions so that one theory of their behavior is valid for one human purpose, another for another. These philosophical differences over the nature of nature itself made it impossible for a good Brāhmaṇa such as Nityānanda or a good Kṣatriya such as Jayasiṃha to receive more of the Muslim interpretation of Ptolemy than some new parameters and the planetary models bereft of the forces that make them move, but regarded purely, as Proclus viewed those of the *Almagest*, as a means to produce mathematically correct predictions of celestial phenomena. In this they were in agreement with the warmest proponents of Islamic astronomy in seventeenth-century Benares. The mere translation of texts, such as is represented by the *Hayatagrantha* or the *Jyotiḥsiddhāntasāra* of Mathurānātha, was not sufficient to produce an Indian Ulugh Beg.

Yet, in a practical sense, some Indians learned to follow the Muslims in their computations. I offer in evidence of this two manuscripts. One, in Poona, discusses in detail the computation of square-roots, sines, and a gnomon's shadow according to Nityānanda's translation of the *Zīj-i Shāh Jahān*.[35] The second, at Berlin, gives detailed computations of the longitudes and latitudes of the Moon and the planets and the longitude of the Sun at noon in Jayapura on Monday 7 March 1718 according to the *Zīj-i Muḥammad Shāh*.[36] Clearly this was computed some years later, after the *Zīj* had been written. That date of computation is approximated by the computations at the end of the manuscript of a lunar eclipse on Sunday 28 May 1732 and of a solar eclipse visible at Jayapura on Monday 20 May 1734. The whole is accompanied by elaborate diagrams and provides ample evidence that its author is technically competent even if not a convert to the philosophical bases of Islamic astronomy.

---

[35] Manuscript 579 of 1895/1902 at the Bhandarkar Oriental Research Institute.

[36] Manuscript or. fol. 2973 at the Städtbibliothek.

Bibliography

Bhaṭṭācārya, V., ed. *Hayatagrantha*. Vārāṇasī, 1967.

Pingree, David. *Census of the Exact Sciences in Sanskrit*. Series A, vols. 1–5. Philadelphia: American Philosophical Society, 1970–1994.

——. "The Greek Influence on Early Islamic Mathematical Astronomy." *Journal of the American Oriental Society* 93 (1973): 32–43.

——. "Māshā'allāh: Some Sasanian and Syriac Sources." In *Essays on Islamic Philosophy and Science*, edited by G. F. Hourani, pp. 5–14. Albany, N.Y.: State University of New York Press, 1975.

——. "The Recovery of Early Greek Astronomy from India." *Journal for the History of Astronomy* 7 (1976): 109–123.

——. "History of Mathematical Astronomy in India." In *Dictionary of Scientific Biography*, vol. 15 (1978), pp. 533–633. 18 vols. New York: Charles Scribner's Sons, 1970–90.

——. "Islamic Astronomy in Sanskrit." *Journal for the History of Arabic Science* 2 (1978): 315–330.

——. *Jyotiḥśāstra: Astral and Mathematical Literature*. Wiesbaden: O. Harrasowitz, 1981.

——. "Indian and Islamic Astronomy at Jayasiṃha's Court." In *From Deferent to Equant: A Volume of Studies in the History of Science in the Ancient and Medieval Near East in Honor of E. S. Kennedy*. Annals of the New York Academy of Sciences, vol. 500, edited by D. A. King and G. Saliba, pp. 313–328. New York, 1987.

——. "The Purāṇas and Jyotiḥśāstra: Astronomy." *Journal of the American Oriental Society* 110 (1990): 274–280.

——. "Āryabhaṭa, the Paitāmahasiddhānta, and Greek Astronomy." *Studies in History of Medicine and Science* 12, no. 1–2, NS (1993): 69–79.

Ragep, F. Jamil. *Naṣīr al-Dīn al-Ṭūsī's* Memoir on Astronomy *(al-Tadhkira fī ᶜilm al-hay'a)*. 2 vols. New York: Springer-Verlag, 1993.